Finnvasc score and modified Prevent III score predict long-term outcome after infrainguinal surgical and endovascular revascularization for critical limb ischemia

Eva Arvela, MD,[a] Maria Söderström, MD,[a] Maria Korhonen, MD,[b] Karoliina Halmesmäki, MD, PhD,[a] Anders Albäck, MD, PhD,[a] Mauri Lepäntalo, MD, PhD,[a] Maarit Venermo, MD, PhD,[a] and **Fausto Biancari, MD, PhD,[c]** *Helsinki and Oulu, Finland*

Background: **Estimation of the risk of adverse long-term outcome is of paramount importance in the treatment of critical limb ischemia (CLI).**

Methods: **We evaluated the accuracy of two specific risk score systems, the Finnvasc score and the modified Prevent III (mPIII) score, in 1425 CLI patients who underwent unilateral, infrainguinal surgical (47.6%) or endovascular (52.4%) revascularization. The receiver operating characteristic (ROC) curve analysis was used to estimate the predictive value of these risk scoring methods.**

Results: **The area under the ROC curve of Finnvasc score for prediction of 30-day amputation was 0.609 (95% confidence interval [CI] 0.549-0.677) and of mPIII score 0.533 (95% CI 0.457-0.609). The area under ROC curve of Finnvasc score for prediction of 30-day amputation-free survival was 0.622 (95% CI 0.573-0.671) and of mPIII score 0.588 (95% CI 0.533-0.642). The area under the ROC curve of Finnvasc score for prediction of 1-year amputation-free survival was 0.630 (95% CI 0.597-0.663, $P < .0001$) and of mPIII score 0.634 (95% CI 0.600-0.667, $P < .0001$). Finnvasc score predicted leg salvage (relative risk [RR] 1.431, 95% CI 1.319-1.551), survival (RR 1.233, 95% CI 1.116-1.363), and amputation-free survival (RR 1.422, 95% CI 1.319-1.534). mPIII score also predicted leg salvage (RR 1.190, 95% CI 1.108-1.277), survival (RR 1.245, 95% CI 1.193-1.300), and amputation-free survival (RR 1.223, 95% CI 1.176-1.272).**

Conclusions: **Finnvasc and modified PIII risk scoring methods predict long-term outcome of patients undergoing infrainguinal revascularization for CLI. Finnvasc score seems to perform well also in predicting immediate postoperative outcome. (J Vasc Surg 2010;52:1218-25.)**

Estimation of the risk of adverse postoperative outcome is of paramount importance in surgery, as it may guide the clinician in the decision-making process, allow planning of resource utilization, enable comparison between different institutions or surgeons, and, last but not least, provide the patient with her/his individual operative risk. This applies particularly to patients with critical leg ischemia (CLI) as the outcome of reconstructed as well as unreconstructed CLI can be rather poor.[1,2] Two recently derived specific risk scoring methods have been shown to reliably predict the 30-day[3,4] and 1-year[5,6] outcome of these patients after surgical revascularization. However, it is unknown whether they may perform well also in estimating the long-term outcome of patients undergoing endovascular surgery, and which one should be preferred for clinical and research purposes. Finnvasc score is useful in predicting immediate postoperative outcome,[3,4] but its usefulness as a predictor of long-term outcome has not been validated earlier. The aim of this study was to evaluate the accuracy of these two specific risk score systems in a series of patients who underwent infrainguinal surgical and endovascular revascularization for CLI.

MATERIAL AND METHODS

A total of 2054 patients with CLI underwent lower limb revascularization in Helsinki University Central Hospital from January 2000 to December 2007. Among them, 1883 patients underwent unilateral, infrainguinal revascularization, and 1425 patients with complete data were included in this study. Data were retrieved from a prospective vascular and endovascular database of our institution (Husvasc). No attempt to replace missing values was made. This study was approved by the Institutional Review Board of Helsinki University Central Hospital.

Clinical characteristics, operative data (shown in the Table), and immediate postoperative outcome data of these

From the Department of Vascular Surgery, Helsinki University Central Hospital;[a] the Department of Radiology, Helsinki University Central Hospital;[b] and the Division of Cardio-Thoracic and Vascular Surgery, Department of Surgery, Oulu University Central Hospital.[c]

Supported by a grant from the Finnish Society for Angiology.

Competition of interest: none.

Reprint requests: Eva Arvela, MD, Department of Vascular Surgery, Helsinki University Central Hospital, PL 340, FI-00029 HUS, Finland (e-mail: eva.arvela@hus.fi).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/$36.00

doi:10.1016/j.jvs.2010.06.101

Table. Clinical and operative characteristics of 1425 patients who underwent isolated infrainguinal revascularization for critical leg ischemia

Variables	*No. (%)*
Age (years)	73.4 ± 11.4
Age ≥75 years	750 (52.6)
Female	708 (49.7)
Diabetes	819 (57.5)
Dyslipidemia	584 (41.0)
Hypertension	1077 (75.6)
Coronary artery disease	909 (63.8)
Cerebrovascular disease	277 (19.4)
Pulmonary disease	215 (15.1)
eGFR (mL/min/1.73 m^2)	65.9 ± 34.1
eGFR class 5	95 (6.7)
Indication for revascularization	
Rest pain	302 (21.2)
Ulcer	905 (63.5)
Gangrene	218 (15.3)
Urgent/emergent procedure	678 (47.6)
Level of revascularization	
Femoropopliteal	699 (49.1)
Crural	623 (43.7)
Pedal	103 (7.2)
Type of revascularization	
Endovascular revascularization	747 (52.4)
Surgical revascularization	678 (47.6)
Finnvasc score	2.1 ± 1.0
0	81 (5.7)
1	321 (22.5)
2	516 (36.2)
3	419 (29.4)
4	88 (6.2)
Modified PIII score	4.3 ± 2.0
0-3	497 (34.9)
4-7	868 (60.9)
8-10	60 (4.2)

eGFR, Estimated glomerular filtration rate.

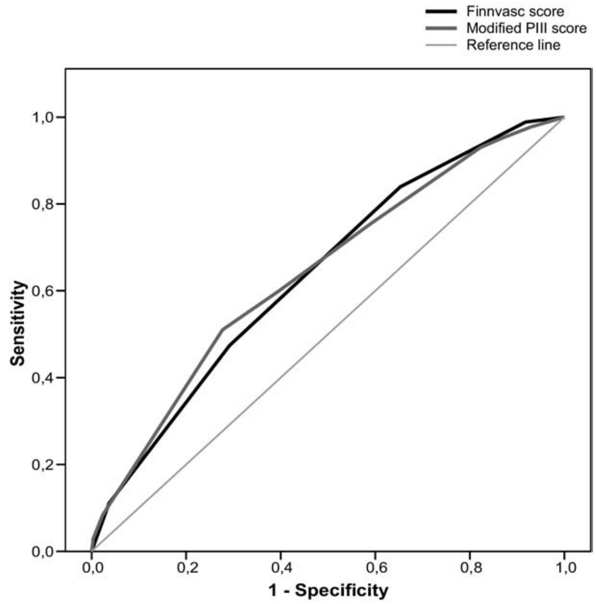


Fig 1. Receiver operating characteristics curve of Finnvasc risk and modified PIII scores in predicting 1-year amputation-free survival.

patients were prospectively collected into our institutional database and scrutinized retrospectively. Date and cause of late death were retrieved from the Finnish national population registry, Statistics Finland. Data on late major lower amputation have been completed retrospectively from files of the National Institute for Health and Welfare. Coronary artery disease (CAD) was defined as previously documented myocardial infarction and/or ongoing angina pectoris or previous coronary bypass surgery or endovascular coronary intervention. Preoperative estimated glomerular filtration rate (eGFR) was calculated according to the modified Modification of Diet in Renal Disease study equation[7,8]: eGFR (mL/min/1.73 m^2) = 186 × (serum creatinine [mg/dL])$^{-1.154}$ × (age)$^{-0.203}$ × 0.742 (if the subject is female) × 1.212 (if the subject is black). Severity of renal failure was classified according to the chronic kidney disease (CKD) classification.[9]

Finnvasc score was derived from a series of 3925 patients who underwent infrainguinal surgical revascularization for CLI and whose data were included in the nationwide Finnvasc registry.[3] Diabetes, coronary artery disease, foot gangrene, and urgent operation were independent predictors of 30-day postoperative mortality and/or major lower-limb amputation, and this risk scoring method was developed by assigning 1 point each to these four risk factors.

Prevent III (PIII) risk scoring method was derived from a prospective, randomized study on the efficacy of edifoligide in preventing autogenous vein graft failure in 1404 patients who underwent infrainguinal vein bypass surgery for CLI.[5] A modified version of the PIII score was proposed by the same authors[6] in which baseline hematocrit was not included due to a large proportion of missing values. Points for calculation of modified PIII were assigned to each patient for the presence of dialysis (4 points), tissue loss (3 points), age ≥75 years (2 points), and coronary artery disease (1 point). The total sum of points was converted score which places the patient in the low (score ≤3), medium (score 4-7), or high risk (score ≥8) category. We did not have the information of number of patients on dialysis, and, therefore for calculation of the modified PIII score, we categorized dialysis as CKD class 5 (eGFR <15 mL/min/1.73 m^2) as it appropriately includes patients with the most severe degree of renal failure.[9]

Outcome end points. Leg salvage, overall survival, and amputation-free survival were the main outcome end points in this study. In order to assess the accuracy of these scoring methods in predicting intermediate outcome, we tested them by the receiver operating characteristic (ROC) curve in predicting 1-year amputation-free survival by excluding patients with follow-up shorter than 1 year.

Statistical analysis. Statistical analysis was performed using SPSS statistical software version 15.0 (SPSS Inc, Chicago, Ill). Continuous data are reported as the mean ±

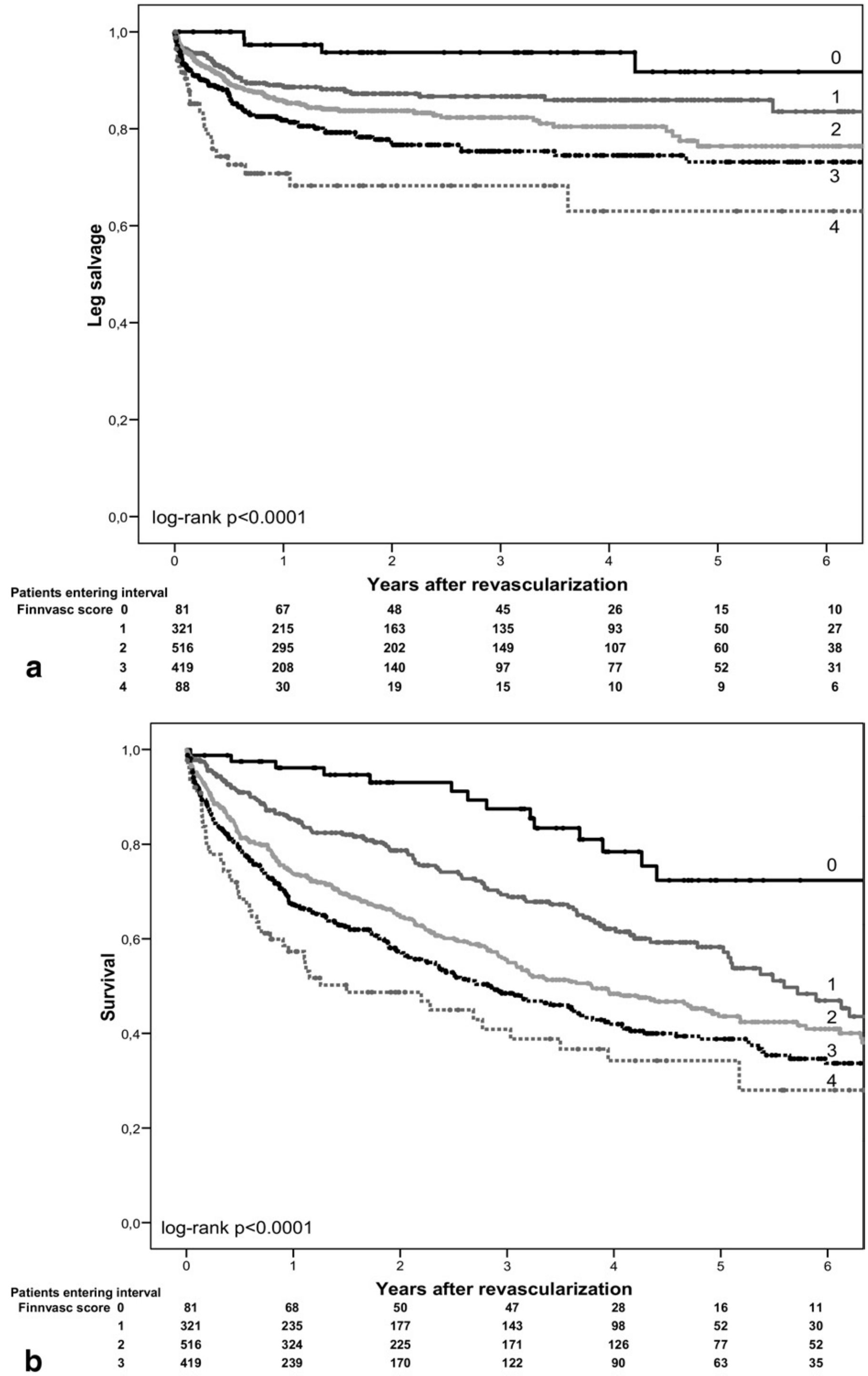
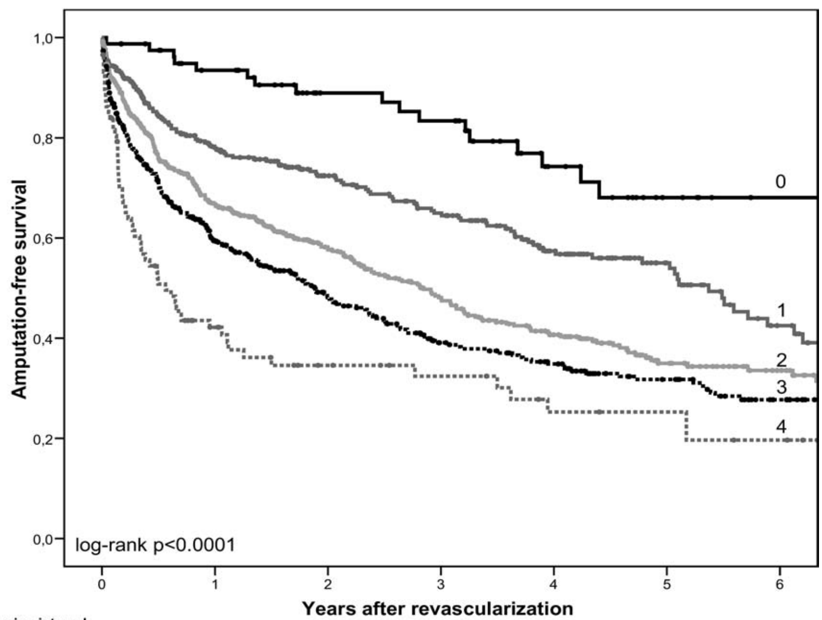


Fig 2. Kaplan-Meier estimates for (**a**) leg salvage, (**b**) survival, and (**c**) amputation-free survival according to different Finnvasc risk score classes. Standard errors (SEs) were <8% throughout the whole time period.

standard deviation. Long-term outcome end points with standard errors (SEs) were estimated by the Kaplan-Meier method. Comparisons between curves were assessed using a Mantel-Cox log rank test for significance. The ROC curve analysis was used to estimate the predictive value of these risk scoring methods in predicting 30-day and 1-year amputation-free survival. ROC curve is a graphic plot of sensitivity and specificity of a continuous variable in pre-



Patients entering interval								
Finnvasc score	0	81	67	48	45	26	15	10
	1	321	215	163	135	93	50	27
	2	516	295	202	149	107	60	38
C	3	419	208	140	97	77	52	31
	4	88	30	19	15	10	9	6

Fig 2. Continued

dicting a dichotomous end point, herein 30-day and 1-year mortality, major amputation and mortality, and/or major amputation. Cox regression analysis with the backward selection was used to adjust these risk scores for anatomic level of revascularization (ie, femoropopliteal, crural, and pedal revascularization), and type of revascularization (ie, surgical vs endovascular revascularization). A *P* value < .05 was considered statistically significant.

RESULTS

The mean follow-up of this study was 2.4 ± 2.2 years (range, 0-7.9 years). Leg salvage rates at 30 days, 1 year, 3 years, and 5 years were 95.3%, 85.2%, 81.5%, and 78.2%, respectively (SE <0.016); survival rates were 95.1%, 74.7%, 57.5%, and 46.6%, respectively (SE <0.018); amputation-free survival rates were 91.1%, 67.2%, 50.4%, and 39.9%, respectively (SE <0.017).

The area under the ROC curve of Finnvasc score for prediction of 30-day amputation was 0.609 (95% confidence interval [CI] 0.549-0.677; *P* = .003) and of modified PIII score was 0.533 (95% CI 0.457-0.609; *P* = .37).

The area under the ROC curve of Finnvasc score for prediction of 30-day amputation-free survival was 0.622 (95% CI 0.573-0.671; *P* < .0001) and of modified PIII score was 0.588 (95% CI 0.533-0.642; *P* = .001).

The area under the ROC curve of Finnvasc score for prediction of 1-year amputation-free survival was 0.630 (95% CI 0.597-0.663; *P* < .0001) and of modified PIII score was 0.634 (95% CI 0.600-0.667; *P* < .0001; Fig 1). In patients who underwent isolated endovascular procedure, the area under the ROC curve of Finnvasc score for prediction of 1-year amputation-free survival was 0.627 (95% CI 0.584-0.671; *P* < .0001) and of modified PIII score was 0.595 (95% CI 0.550-0.640; *P* < .0001). In patients who underwent surgical revascularization, the area under the ROC curve of Finnvasc score was 0.658 (95% CI 0.612-0.704; *P* < .0001) and of modified PIII score was 0.677 (95% CI 0.629-0.725; *P* < .0001).

Kaplan-Meier estimates of leg salvage, survival, and amputation-free survival for Finnvasc score and modified PIII score are shown in Figs 2 and 3. A total of 135 patients entered 6-year interval at survival analysis and 112 patients in amputation-free survival analysis. Both risk scores performed well in predicting the main long-term outcome end points.

Cox regression analysis showed that when adjusted for anatomic level of revascularization (ie, femoropopliteal, crural, and pedal revascularization), elective versus urgent/emergent procedure, and type of revascularization (ie, surgical vs endovascular revascularization), Finnvasc risk score was independent predictor of leg salvage (*P* = .001; relative risk [RR] 1.322; 95% CI 1.122-1.558), survival (*P* < .0001; RR 1.483; 95% CI 1.344-1.636), and amputation-free survival (*P* < .0001; RR 1.422; 95% CI 1.319-1.534). Modified PIII risk score adjusted for the above mentioned variables was independent predictor of leg salvage (*P* < .0001; RR 1.160; 95% CI 1.080-1.247), survival (*P* <

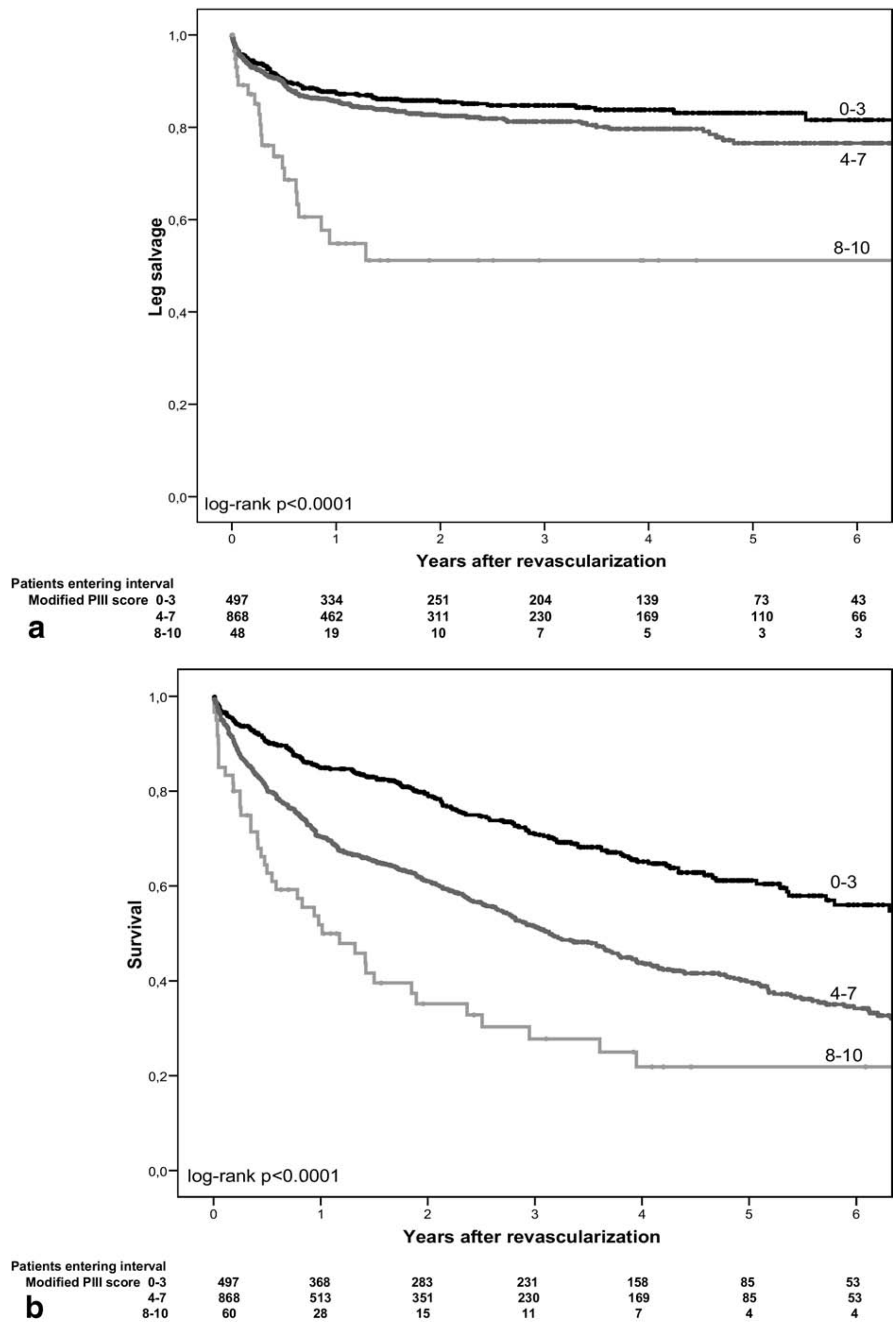


Fig 3. Kaplan-Meier estimates for (**a**) leg salvage, (**b**) survival, and (**c**) amputation-free survival according to different modified PIII risk score classes. Standard errors (SEs) were <9% throughout the whole time period.

.0001; RR 1.241; 95% CI 1.189-1.295), and amputation-free survival ($P < .0001$; RR 1.219; 95% CI 1.170-1.270) as well.

DISCUSSION

During the last decades, a large amount of studies have assessed the outcome of revascularization procedure for lower limb ischemia and identified a number of risk factors associated with poor outcome. It is evident that the nature of failed lower limb revascularization is largely multi-factorial. Some factors are technical (ie, suboptimal graft material[10] and poor run-off status[11]) and others are patient-related (ie, severe comorbidities so often associated with CLI). The severity of atherosclerosis involv-

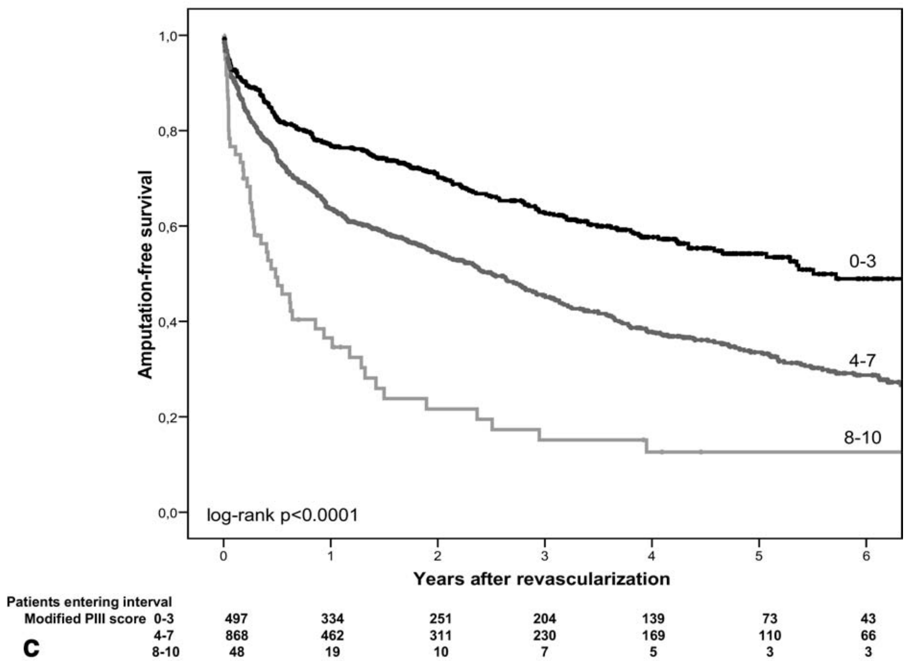


Fig 3. Continued

ing lower limb arteries and the degree of ischemia and its related complications, such as ulcer and gangrene are major determinants of outcome. Indeed, in a few cases, major amputation is required despite a patent bypass graft because of irreversible ischemic tissue changes and infection.[12-13] Varu et al,[14] in their recent review, even suggested conservative treatment or primary amputation for CLI patients older than 75 years. However, Biancari et al[3] found that age was not an independent predictor of postoperative death and/or limb loss. Indeed, in our series, more than half of the patients were older than 75 years of age, and they had a large number of comorbidities. In addition to technical and patient-related factors, referral pathway, multidisciplinary approach, and activity of revascularization policy have certainly impacted the outcome.[15-17] Inclusion of these numerous risk factors into a risk scoring method would result in a complicated score that would not be easy to use for clinicians and otherwise not necessarily accurate. The herein evaluated risk-score methods showed that, despite being very simple and including easily retrievable variables, they can be rather accurate and identify those patients with markedly poor long-term outcome. Certainly the area under the ROC curve for both risk scores in predicting 1-year amputation-free survival are not optimal, and this suggests the complex nature of late failures and the difficulties to derive a specific CLI risk scoring method.

The main difference between these two risk scoring methods is that modified PIII score includes renal failure as one factor, whereas Finnvasc does not. Indeed, patients with renal failure and critical limb ischemia undergoing infrainguinal bypass have poorer postoperative survival and higher amputation rates.[18-20] On the other hand, Finnvasc score separates foot gangrene as one risk factor, but in modified P III score, gangrene and ulcer are considered as one equivalent factor. Yet, there are data suggesting that gangrene is a stronger independent risk factor for poor outcome than stable ulcer.[21,22]

As observed in this study, Finnvasc score was predictive of the immediate postoperative outcome, whereas modified PIII score was not quite so accurate, especially when leg salvage was considered. Also in this case, the area under the ROC curve of Finnvasc score was far from being optimal. An explanation for this difference might be that Finnvasc score emphasizes the presence of foot gangrene, and might therefore be a more accurate predictor of immediate leg salvage. Otherwise, both risk scores showed to perform well in predicting late outcome (Figs 2 and 3).

From a clinical point of view, the most important benefit of these scoring methods might be their ability to help to identify the patients whose poor outcome estimates would suggest conservative approach. The present results show that Finnvasc score 4 and modified PIII scores 8 to 10 are associated with particularly low expectancy of leg salvage and survival. The amputation-free survival curve is particularly steep in these patients as most of them died and/or had a major amputation within 1 year after revascularization. The number of such high-risk patients is rather small (6.2% and 4.2%, respectively), and these risk scoring methods may indicate when any revascularization attempt in such cases could be contraindicated and a conservative strategy more appropriate. Furthermore, as noticed also in previous risk scoring studies, when trying to predict postoperative or long-term outcome from preoperative data in vascular surgical patients, it is easier to predict the patients with good outcome.[23,24] However, the proportion of patients with extremely poor outcome has been low as in our study, which may be a result of good preoperative patient selection.[23]

This validation study showed that both Finnvasc score and modified PIII score perform rather well also in patients undergoing endovascular procedures, even if they have been derived from patients who underwent surgical revascularization. Indeed, poor early outcome is expected in high-risk patients undergoing endovascular revascularization[4,25] In fact, the minimally invasive nature of this treatment method may easily generate a false sense of safety toward endovascular treatments in such a fragile patient population. The present study suggests that identification of high-risk patients by these risk scores may allow a more critical decision-making process and better allocation of resources toward patients who are more likely to benefit from revascularization. In the future, the need of vascular surgery will increase significantly as the elderly and diabetic population increases, and therefore it becomes even more important to focus on those patients that will gain benefit from the procedures.

This study has a few limitations. We did not have the data on dialysis status, a risk factor included into the modified PIII risk score. Therefore we assigned 4 points to class V of the CKD classification as it may better categorize those patients with kidney failure,[9] but not yet on dialysis therapy despite the severity of renal failure. There are also data suggesting that independent of dialysis status, eGFR predicts long term survival after lower limb revascularization.[26]

In conclusion, Finnvasc and modified PIII risk scoring methods predict the long-term outcome of patients undergoing both surgical and endovascular infrainguinal revascularization for CLI. Finnvasc score seems to perform well also in predicting immediate postoperative outcome. The accuracy of these risk scores is acceptable. These risk scores are rather easy to use and could be valuable in the clinical setting, especially as an aid to decide when not to revascularize.

We would like to thank study nurse Anita Mäkelä for invaluable help in data collection.

AUTHOR CONTRIBUTIONS

Conception and design: MV, ML, FB
Analysis and interpretation: EA, AA, MV, ML, FB
Data collection: EA, MS, MK, KH, MV
Writing the article: EA, ML, MV, FB
Critical revision of the article: EA, MS, MK, KH, AA, ML, MV, FB
Final approval of the article: EA, MS, MK, KH, AA, ML, MV, FB
Statistical analysis: ML, MV, FB
Obtained funding: N/A
Overall responsibility: FB

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Submitted Apr 7, 2010; accepted Jun 7, 2010.